

Docket No.: SON-1745 (PATENT)

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Patent Application of:
Seiichi FUKUDA

Confirmation No.: 5387

Application No.: 09/512,336

Art Unit: 1765

Filed: February 24, 2000

Examiner: K. Chen

For: DRY ETCHING METHOD AND METHOD
OF MANUFACTURING SEMICONDUCTOR
APPARATUS

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APPELLANT'S BRIEF

MS Appeal Brief - Patents
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

This is an Appeal Brief filed under 37 C.F.R. § 1.192 appealing the Final Rejection of the Primary Examiner dated June 9, 2003 (Paper No. 23). A Notice of Appeal was timely filed on August 22, 2003. The fees required under § 1.17(f), and any required petition for extension of time for filing this brief and fees therefore, are dealt with in the accompanying TRANSMITTAL OF APPEAL BRIEF. This brief is transmitted in triplicate.

This brief contains items under the following headings as required by 37 C.F.R. § 1.192 and M.P.E.P. § 1206:

- I. Real Party in Interest
- II. Related Appeals and Interferences
- III. Status of Claims
- IV. Status of Amendments
- V. Summary of Invention
- VI. Issues
- VII. Grouping of Claims
- VIII. Arguments
- IX. Claims Involved in the Appeal

Appendix A: Claims

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I. REAL PARTY IN INTEREST

Sony Corporation of Tokyo, Japan ("Sony") is the real party in interest of the present application. An assignment of all rights in the present application to Sony was executed by the inventor and recorded by the U.S. Patent and Trademark Office on February 24, 2000 at **Reel 10625, Frame 131**.

II. RELATED APPEALS AND INTERFERENCES

There are no appeals or interferences related to the present application of which the Appellant is aware that will directly affect or be directly affected by or have a bearing on the Board's decision in the pending matter.

III. STATUS OF CLAIMS

A. Total Number of Claims in Application

There are 4 claims pending in the present application. Claims 1, 4, 5 and 6 stand finally rejected. No claims are currently allowed. Accordingly, the Appellants hereby appeal the final rejection of claims 1, 4, 5 and 6, each of which is presented in Appendix A.

B. Current Status of Claims

1. Claims canceled: 2, 3, 7, 8
2. Claims withdrawn from consideration but not canceled: None
3. Claims pending: 1, 4, 5, 6
4. Claims allowed: None
5. Claims rejected: 1, 4, 5, 6

C. Claims on Appeal

The claims on appeal are claims 1, 4, 5 and 6.

IV. STATUS OF AMENDMENTS

The application as filed contained claims 1 to 8. In response to the First Office Action on the merits dated March 1, 2001 (Paper No. 4), Appellants amended claims 1 to 4 and 6 to 8. In response to the Second Office Action on the merits dated June 21, 2001 (Paper No. 6), Appellants again amended claims 1 and 4. These amendments, however, were not entered until after Appellant's First Request for Continued Examination was filed on November 11, 2001. In response to the final Office Action of July 9, 2002 (Paper No. 14), Appellants cancelled claims 2, 3, 7 and 8, and again amended claims 1 and 4. Later, by way of a Second After Final Amendment filed on November 14, 2002, claims 1 and 4 were again amended by Appellant.

These amendments were not entered until after Appellant's Second Request for Continued Examination was filed on January 7, 2003. Finally, in response to the non-final Office Action of May 14, 2003 (Paper No. 21), Appellants again amended claims 1 and 4.

No amendments to the claims have been made since the Final Office Action dated September 9, 2003 (Paper No. 23), which is the subject of this Appeal. Claims 1, 4, 5 and 6 stand finally rejected. Accordingly, the claims in the Appendix represent the state of the claims as pending.

V. SUMMARY OF INVENTION

The present invention is directed to the use of a very particular combination of gases for the purpose of dry etching a metal film having specific properties such as those of tungsten, and for making a semiconductor apparatus using the same combination of gases.

As discussed on page 4, lines 3-18 of the specification, when high-order fluorine gases such as sulphur hexafluoride (SF_6) are employed for dry-etching tungsten, the quantity of fluorine radicals present in the etching process increases dramatically. This increase in fluorine radicals results in a non-uniform etching of the tungsten layer, otherwise known as microloading. As shown in Fig. 4, the effects of microloading are characterized by a *reduced* etching rate in regions in which hairlines are formed densely and conversely by an *increased* etching rate in a region in which hairlines are more isolated from one another, thereby resulting in non-uniform etching of the tungsten layer. (See page 4, lines 3-10).

Further, as described on page 3, lines 6-15 of the specification, when the above-described high-order fluorine gases are used in a method of manufacturing a semiconductor apparatus, the high number of fluorine radicals present results in a large degree of asperities, which serve to weaken a gate insulating film of the semiconductor apparatus. Consequently, when the degree of asperities becomes too large, the gate insulating film may break, resulting in failure of the semiconductor apparatus. (See page 3, lines 15-18).

Accordingly, an object of the present invention is to provide a method of dry-etching a tungsten film with satisfactory shape controllability such that the adverse effects of microloading

can be successfully reduced. Another object of the present invention is to provide a method of manufacturing a semiconductor apparatus capable of forming a gate electrode constituted by laminating tungsten without any breakage in a gate insulating film.

The dry etching method of claim 1 of the present invention involves dry-etching a formed film of tungsten through its entire thickness as originally formed using only a single mixed gas. This single mixed gas includes a fluorine-containing gas, oxygen, nitrogen and either chlorine or hydrogen bromide. As described on page 6, lines 15-21, the fluorine-containing gas recited in claim 1 includes a compound having fluorine and carbon in a molecule (otherwise known as a fluorocarbon) and has a structure such that the number of fluorine atoms in elements which constitute the gas molecule is four or less. In other words, only fluorocarbon gas molecules which contain four or less fluorine atoms, as is the case in CF_4 , CHF_3 , CH_2F_2 or CHF_3 , for example, may be used for the fluorine-containing gas recited in claim 1. As explained on page 7, lines 3-6 of the specification, when the number of fluorine atoms in a fluorine-containing gas used in a process for dry-etching a tungsten film is four or less, the number of fluorine radicals generated is reduced such that a slower, more practical etching rate can be realized. Accordingly, the adverse effects of microloading are reduced.

The method for manufacturing a semiconductor apparatus of claim 4 comprises the steps of laminating upwards a polysilicon film or an amorphous film, a tungsten nitride film or a titanium nitride film, and a tungsten film on a silicon substrate. The tungsten nitride film, or the titanium nitride film and the tungsten film, are then dry-etched through their entire thickness as originally formed by the specific combination of gases recited in claim 1 such that a gate electrode is formed. As a result of using the above-recited method, the tungsten, tungsten nitride or titanium nitride films are etched at a slower, more practical speed such that the effects of microloading are reduced, as explained above. Accordingly, damage to the gate insulating film and the like formed below the gate electrode is prevented. (See page 27, lines 5-10).

VI. ISSUES

The issues presented for consideration in this appeal are as follows:

(1) Whether the Examiner erred in rejecting claim 1 under 35 U.S.C. §103(a) as being obvious over U.S. Patent No. 6,146,542 to Ha et al. ("Ha") in view of U.S. Patent No. 5,024,722 to Cathey, Jr. ("Cathey") or U.S. Patent No. 5,846,886 to Hattori et al. ("Hattori")?

(2) Whether the Examiner erred in rejecting claims 4, 5 and 6 under 35 U.S.C. § 103(a) as being obvious over U.S. Patent No. 6,146,542 to Ha et al. ("Ha") in view of U.S. Patent No. 5,024,722 to Cathey, Jr. ("Cathey") or U.S. Patent No. 5,846,886 to Hattori et al. ("Hattori") and further in view of U.S. Patent No. 6,296,780 B1 to Yan et al. ("Yan")?

VII. GROUPING OF CLAIMS

For purposes of this appeal brief only, and without conceding the teachings of any prior art reference, each of the remaining claims, specifically claims 1, 4, 5 and 6, stand or fall together. Arguments supporting the patentability of this claim set are set forth below.

VIII. ARGUMENTS

Each of the claims on appeal were rejected under 35 U.S.C. § 103 as being obvious in view of the applied art. The test for obviousness is what the combined teachings of the prior art would have suggested to one of ordinary skill in the art. See, e.g., In re Keller, 642 F. 2d 413, 425, 208 USPQ 871, 881 (CCPA 1981). In establishing a *prima facie* case of obviousness, it is incumbent upon the Examiner to provide a reason why one of ordinary skill in the art would have been led to modify a prior art reference or to combine reference teachings to arrive at the claimed invention. See Ex parte Clapp, 227 USPQ 972, 973 (Bd.Pat.App. & Interf. 1985). To this end, the requisite motivation must stem from some teaching, suggestion or inference in the prior art as a whole or from the knowledge generally available to one of ordinary skill in the art, and not from the Appellant's disclosure. To reach this analysis, proper findings are required.

It is fundamental to this appeal that the findings of fact upon which the Examiner relied to consider the claims are not accurate or supported by substantial evidence. Therefore, the Examiner has failed to make a *prima facie* finding of obviousness sufficient to withstand this scrutiny. Moreover, there is insufficient motivation to make the combination proposed by the Examiner. Therefore, the rejection of all claims should be reversed.

A. Claim 1 is not Obvious in View of Ha and in View of Cathey or Hattori

In the action, claim 1 was rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent No. 6,146,542 ("Ha") in view of either U.S. Patent No. 5,024,722 ("Cathey") or U.S. Patent No. 5,846,886 ("Hattori"). These rejections are respectfully traversed.

The present invention is directed to the use of a very particular combination of gases for the purpose of dry etching a metal having specific properties such as those of tungsten, and for making a semiconductor apparatus using the same combination of gases. The background section of the present application teaches that the combination of gases is important, as none of the gases alone is sufficient to accomplish the purposes of the inventive methods. There is no doubt that the individual gases used in the etching combination are not new themselves. There is also no doubt that some of these gases are well known to be used in combination for the purpose of etching tungsten. However, as will be established below, the exact combination of gases in the methods of the present invention is new, and there is no teaching or suggestion in the prior art of record for combining the known gases in the manner disclosed and claimed.

The dry-etching method disclosed in Ha teaches that a metallic layer such as tungsten may be etched using a compound mixed gas containing a first gas including at least two of O₂, N₂ and CO, a second gas including fluorine, a third gas including chlorine and a fourth gas including bromide. (See column 3, lines 30-65). While the second gas recited in Ha is disclosed as including fluorine, notably absent from this gas is the inclusion of carbon in the same molecule. In other words, Ha fails to disclose, teach or suggest the compound mixed gas as containing a "fluorine-containing gas that includes a compound having fluorine *and carbon* in a molecule", as is recited in claim 1 of the present invention. Instead, the Ha patent teaches in its background section that the etching of the tungsten film is performed using fluorine gases such as SF₆ and NF₃, each of which do *not* contain carbon. (See column 1, lines 40-48).

This point is further established by the fact that Ha goes on to disclose that while a non-carbon-containing fluorine gas is used in etching the tungsten layers, a carbon-containing fluorine plasma may be used in a subsequent etching step, not to remove the tungsten layers, *but to remove the etching barrier layer formed of polysilicon*. (See column 4, lines 5-8). Therefore, a person of ordinary skill in the art would read Ha as teaching that the fluorine gas included in

the compound mixed gas used for etching tungsten does not include a carbon in the same molecule, but is instead made up of non-carbon-containing fluorine gases, such as SF₆ and NF₃.

In addition, while claim 1 of the present invention recites that the total number of fluorine atoms in the gas molecule containing fluorine and carbon must be four or less, Ha teaches that the number of fluorine atoms in the fluorine gas may be as high as six. This is shown by Ha's express adoption of NF₆ as an acceptable fluorine gas for use in the compound mixed gas used for etching the tungsten layers. (See column 4, lines 5-8).

In section 2 of the Final Office Action dated June 9, 2003 (Paper. No. 23), the Examiner agreed with and expressly adopted these findings of fact. In that Action, the Examiner found that "Ha does not explicitly state that the gas containing fluorine gas may include a compound having fluorine and carbon in a molecule." Consequently, in order for claim 1 of the present invention to be rendered obvious, there must be some teaching somewhere in the prior art that the fluorine gases of SF₆ and/or NF₃ used in Ha's etching gas combination should be modified and/or replaced with a carbon-containing fluorine gas wherein the total number of fluorine atoms in the gas molecule is four or less.

Cathey and Hattori clearly fail to suggest such a modification or replacement. As disclosed in column 6, lines 48-55, the Cathey reference, which is directed to a process for defining conductors on an integrated circuit substrate, teaches that tungsten layers may be etched by using either SF₆ (sulfur hexafluoride), NF₃ (nitrogen trifluoride) or CF₄ (carbon tetrafluoride). The Hattori reference, which is directed to a metal film etching method, additionally teaches that a preferable fluorine gas may be any one of CF₄, C₂F₆, C₃F₈, NF₃ and SF₆. (See column 1, lines 49-50). Consequently, in an attempt to remedy the conceded deficiencies of Ha, the Examiner asserted in Section 2 of the Final Office Action of June 9, 2003 that "it would be obvious to use CF₄ to etch tungsten rather than using NF₃ or SF₆ in Ha's process because Cathey Jr. or Hattori teaches the equivalence among these etchants for etching tungsten." The present invention, however, teaches that the fluorine gases recited in both Cathey and Hattori are not equivalents.

As disclosed on page 4, lines 3-18 of the specification, when high-order fluorine gases such as sulphur hexafluoride (SF₆) are employed for dry-etching tungsten, the quantity of fluorine radicals increases dramatically. This increase in radicals results in a non-uniform etching of the

tungsten layer, otherwise known as microloading. (See Fig. 4). The adverse affects of microloading, however, are successfully avoided when a carbon-containing fluorine gas is used in which the total number of fluorine atoms in the gas molecule is four or less. (See page 7, lines 1-6). Examples of such fluorine gas molecules include CF_4 , CHF_3 , CH_2F_2 and CHF_3 . (See page 6, lines 19-21). As explained on page 7, lines 1-6 of the specification, when the number of fluorine atoms in a carbon-containing fluorine gas used in a process for dry-etching a tungsten film is four or less, the number of fluorine radicals generated is reduced such that a slower, more practical etching rate can be realized. Accordingly, the adverse effects of microloading are reduced.

In other words, distinct advantages are attained when carbon-containing fluorine gases having four or less total fluorine atoms are used, such as CF_4 , instead of high-order fluorine gases, such as SF_6 , or non-carbon containing fluorine gases, such as NF_3 , in conjunction with the presently disclosed combination of gases for dry-etching tungsten. Accordingly, these distinct advantages show that the use of carbon-containing fluorine gases having four or less total fluorine atoms, such as CF_4 , in conjunction with the presently disclosed mixed gas for dry-etching tungsten, is not equivalent to the use of either SF_6 or NF_3 . The discovery and application of this unique advantage represents a portion of the novelty of the present invention sought to be patented by the Appellants.

More importantly, Ha, Cathey and Hattori each clearly fail to provide solutions to the significant adverse effects of microloading experienced in conventional tungsten dry-etching methods. Specifically, the use of either of the fluorine gases disclosed in the Ha reference (NF_3 , which does not contain a carbon and SF_6 , which contains more than 4 fluorine atoms and also does not contain a carbon) would result in adverse microloading effects. The same is true for 2 out of 3 of the fluorine gases disclosed in Cathey (SF_6 and NF_3), as well as for 4 out of 5 of the fluorine gases disclosed in Hattori (C_2F_6 and C_3F_8 , both of which contain more than 4 fluorine atoms, and SF_6 and NF_3).

In fact, out of the five different "acceptable" fluorine gases disclosed in Ha, Cathey and Hattori, only one, CF_4 , has been found to successfully avoid the adverse effects of microloading. (See Example 1 on pages 14 to 19 of the specification of the present invention). In other words,

if a person of ordinary skill in the art were to attempt to dry-etch a tungsten layer according to the methods and gases disclosed in the three references cited by the Examiner, this person would be at least 80% likely to experience the adverse effects of microloading.

Moreover, it is again emphasized that the present invention is not directed to a single etching gas, but a very particular combination of gases resulting in a mixed gas. The replacement of one gas for another in a particular combination of gases, like the Ha combination, must be done with some motivation, and the broad assertion that one gas is a known tungsten etchant is not sufficient motivation to replace one gas for another gas in a specific combination of gases, especially when there is no teaching or suggestion that the particular combination is in any way deficient or in need of improvement. Thus, a person of ordinary skill in the art would not be motivated from reviewing the references as a whole to replace the fluorine gases disclosed in Ha, SF₆ or NF₃, with the fluorine gas disclosed in Cathey or Hattori, CF₄. This is particularly true in light of Ha's inherent teaching away from making such a replacement, as discussed above.

Therefore, because Ha admittedly fails to teach of a method for dry-etching tungsten using a mixed gas containing a fluorocarbon wherein the number of fluorine atoms is four or less, and because the use of CF₄ in conjunction with the particular combination of gases recited in claim 1 for etching tungsten is not equivalent to the use of NF₃ or SF₆, and further because Ha, Cathey and Hattori fail to suggest a need for replacing the fluorine gases disclosed in Ha with the CF₄ gas disclosed in Cathey or Hattori, one skilled in the art at the time the invention was made would lack the requisite motivation to modify and combine the teachings of Cathey or Hattori with those of Ha.

Accordingly, Appellants assert that the rejection of claim 1 fails to establish a *prima facie* case of obviousness because there is no suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine the reference teachings.¹ The mere fact that references can be combined or modified does not render the resultant combination obvious unless the prior art also

¹ *In re Linter*, 458 F.2d 1013, 173 USPQ 560, 562 (CCPA 1972).

suggests the desirability of the combination.² To do so would be an impermissible use of hindsight reconstruction from Appellants' disclosure.³ It would appear that any suggestion or motivation of such a replacement or substitution as suggested by the Examiner flows, not from the prior art going forward toward the invention claimed, but in a hindsight manner based on the teachings of the specification. For the claimed combination, there are no motivating teachings found to support factually the proposed substitution in light of the foregoing arguments. Withdrawal of this rejection is therefore respectfully requested.

B. Claims 4, 5 and 6 are not Obvious in View of Ha and in View of Either Cathey or Hattori, and Further in View of Yan

In the Final Office Action of June 9, 2003, claims 4, 5 and 6 were rejected under 35 U.S.C. § 103(a) as allegedly being unpatentable over Ha in view of either Cathey or Hattori, and further in view of U.S. Patent No. 6,296,780 B1 ("Yan"). In addition to other novel features and distinctions recited therein, claims 4, 5 and 6, which recite essentially the same chemical limitations as those recited in claim 1, are also patentable over Ha, Cathey and Hattori for at least the reasons set forth above.

Moreover, the Yan reference cited by the Examiner fails to compensate for the deficiencies of the prior art discussed above with respect to claim 1. While the Yan reference mentions that carbon-containing fluorine gas may be used to process an organic anti-reflective coating (OARC) layer and a titanium nitride anti-reflective coating (TiN ARC) layer, the Yan reference fails to disclose, teach or suggest that the use of these carbon-containing fluorine gases, in conjunction with the claimed combination of gases, would be either effective or desirable for use in etching tungsten layers. (See column 3, lines 48-55).

In addition, while the Yan reference discloses the use of carbon-containing fluorine gases, this reference fails to disclose, teach or suggest the necessity of only using such carbon-containing fluorine gases when the number of fluorine atoms in such gases is four or less. In fact, as described in column 4, lines 5-22, a number of the carbon-containing fluorine gases which are disclosed as being "acceptable" gases for use in etching the OARC and TiN ARC

² *In re Mills*, 916 F.2d 680, 16 USPQ2d 1430 (Fed. Cir. 1990).

³ *In re Dembiczak*, 50 USPQ2d 1614 (Fed. Cir. 1999).

⁴ *In re Royka*, 490 F.2d 981, 180 USPQ 580 (CCPA 1974).

layers of Yan contain more than 4 fluorine atoms. As discussed above, the use of such fluorine gases when etching tungsten results in adverse microloading effects.

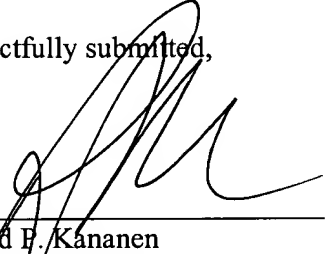
Accordingly, because Yan fails to remedy the conceded deficiencies of Ha, and further because, as described above, Cathey and Hattori additionally fail to remedy the conceded deficiencies of Ha, one of ordinary skill in the art at the time the invention was made would lack the requisite motivation to combine the teachings of Ha, Cathey, Hattori, and Yan in order to render claims 4, 5 and 6 of the present invention obvious.

IX. CLAIMS INVOLVED IN THE APPEAL

A copy of the claims involved in the present appeal is attached hereto as Appendix A. As indicated above, the claims in Appendix A represent the state of the claims as pending.

Dated: October 20, 2003

Respectfully submitted,

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**APPENDIX A****Claims Involved in the Appeal of Application Serial No. 09/512,336**

1. (Previously Presented) A dry etching method comprising the step of:

dry-etching a formed film of tungsten through its entire thickness as originally formed using only a single mixed gas including a fluorine-containing gas that includes a compound having fluorine and carbon in a molecule, chlorine or hydrogen bromide, oxygen, and nitrogen,

wherein said fluorine-containing gas has a structure that a ratio of fluorine atoms with respect to elements of the gas molecule except for fluorine is four or less when the composition of the fluorine molecule is M_xF_y , $Y/X \leq 4$ where M is an element except for fluorine atom and F is fluorine, and the total number of fluorine atoms in elements constituting said gas molecule is four or less.

2. (Cancelled)

3. (Cancelled)

4. (Previously Presented) A method of manufacturing a semiconductor apparatus comprising the steps of:

laminating upwards a polycrystal silicon film or an amorphous silicon film, a tungsten nitride film or a titanium nitride film, and a tungsten film on a silicon substrate; and

performing a dry-etching of said tungsten nitride film through its entire thickness as originally formed, or said titanium nitride film and said tungsten film through its entire thickness as originally formed, with only a single mixed gas containing fluorine-containing gas that includes a compound having fluorine and carbon in a molecule, chlorine or hydrogen bromide, oxygen and nitrogen so that a gate electrode is formed,

wherein said fluorine-containing gas has a structure that a ratio of fluorine atoms with respect to elements of the gas molecule except for fluorine is four or less when the composition of the fluorine molecule is M_xF_y , $Y/X \leq 4$ where M is an element except for

fluorine atom and F is fluorine, and the total number of fluorine atoms in elements constituting said gas molecule is four or less.

5. (Original) A method of manufacturing a semiconductor apparatus according to claim 4, wherein said gate electrode is formed by dry-etching said polycrystal silicon film or said amorphous silicon film with gas which does not contain fluorine.

6. (Previously Presented) A method of manufacturing a semiconductor apparatus according to claim 4, wherein a mask is formed by silicon oxide or silicon nitride, and said gate electrode is formed by dry etching using said mask.

7. (Cancelled)

8. (Cancelled)